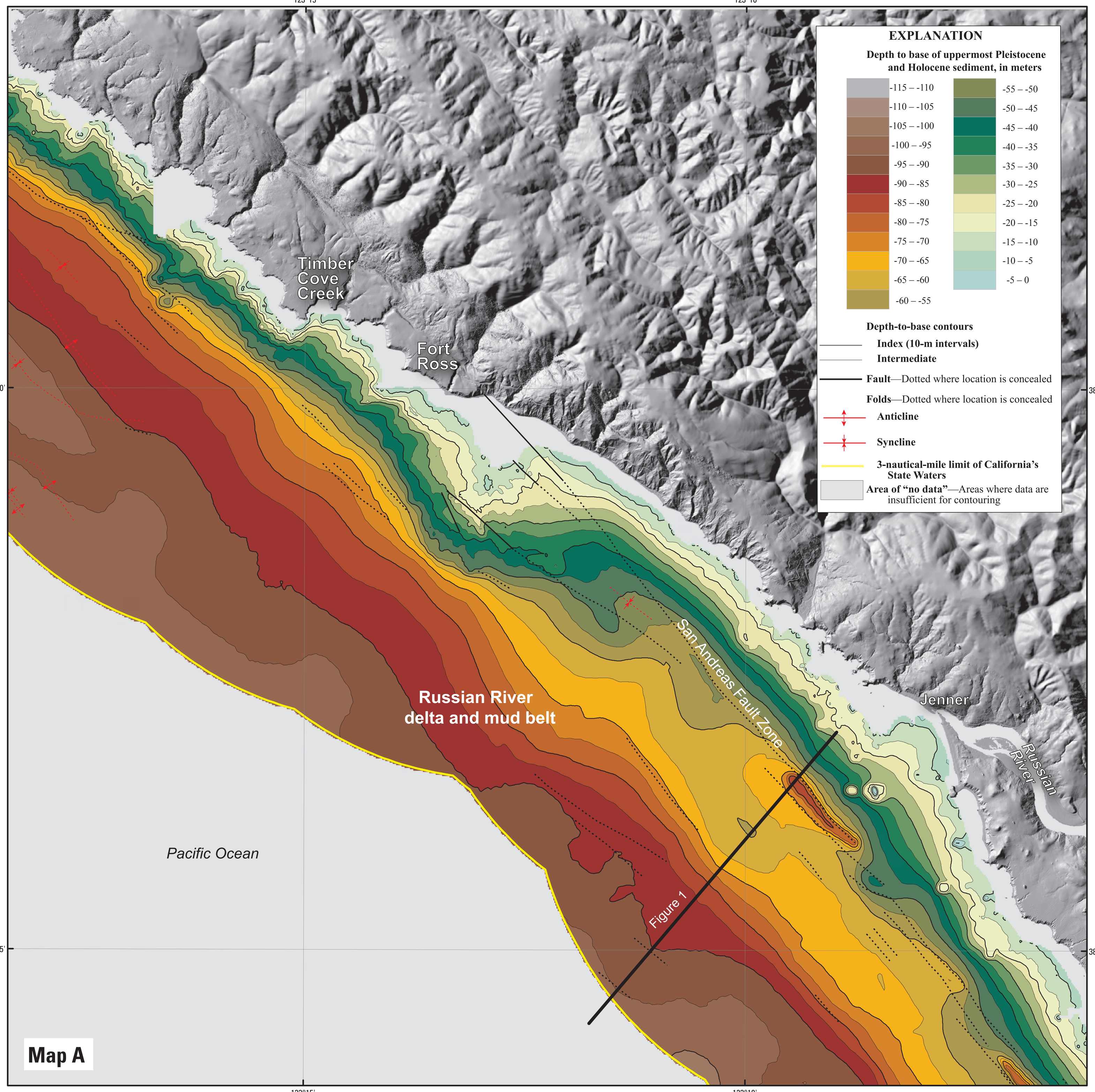
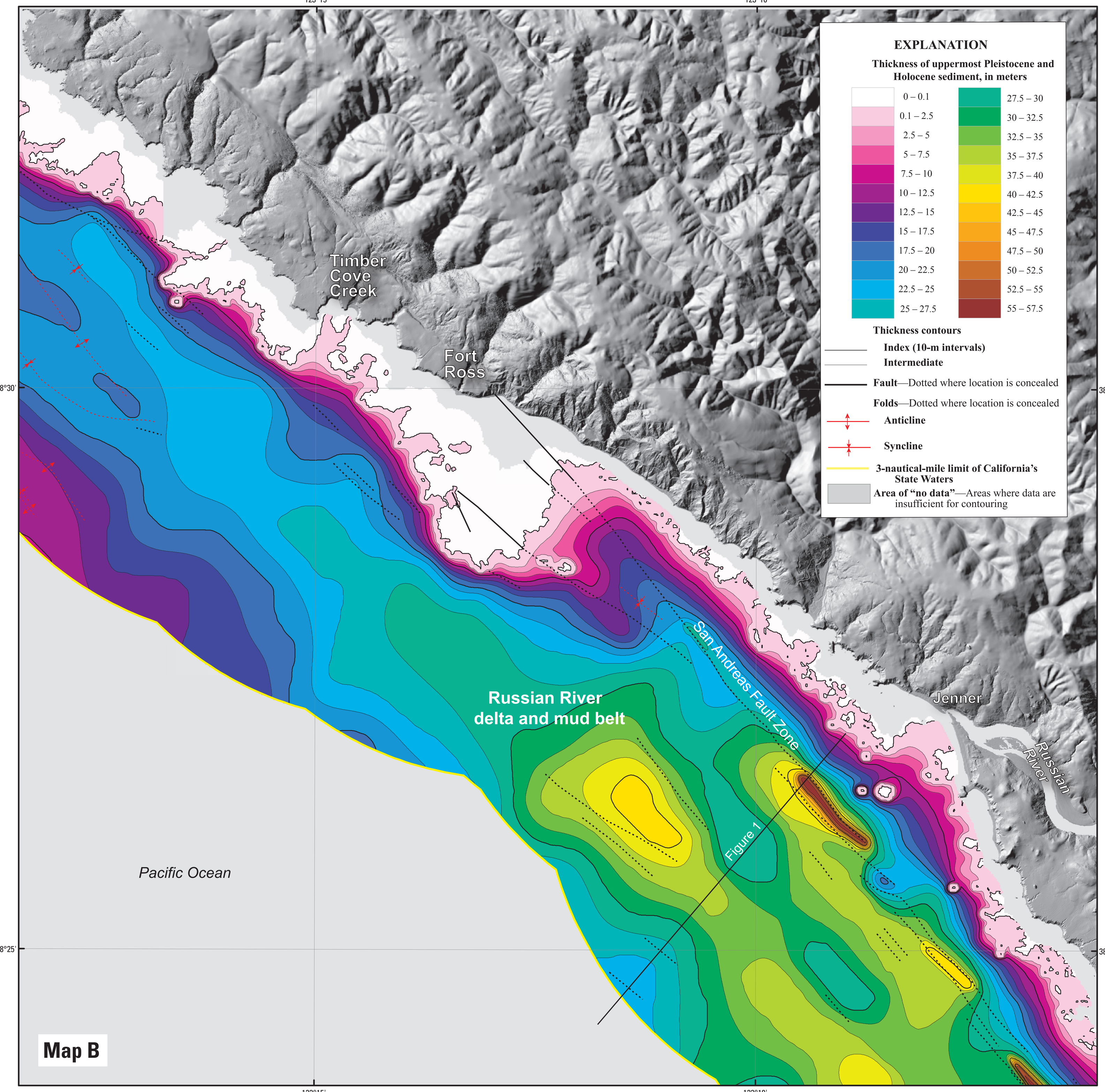
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1211
Sheet 9 of 10
Pamphlet accompanies map





Onshore elevation data from National Oceanic and Atmospheric Administration's (NOAA's) Digital Coast (available at http://coast.noaa.gov/digitalcoast/data/coastallidar/), from OpenTopography (available at http://www.opentopography.org/), and from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

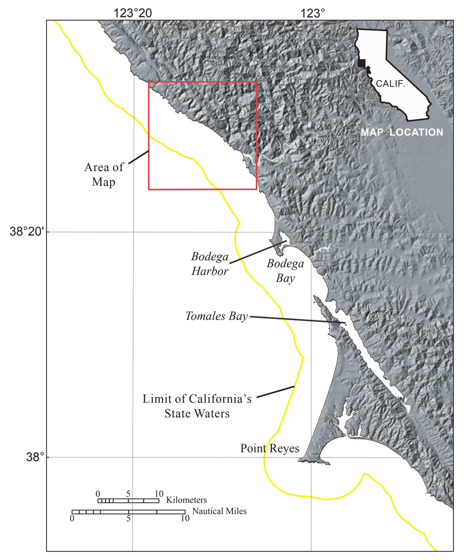
NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:50 000

ONE MILE = 0.869 NAUTICAL MILES

Depth and thickness mapped by Samuel Y. Johnson and Steven R. Hartwell, 2012–2013
GIS database and digital cartography by Stephen R. Hartwell



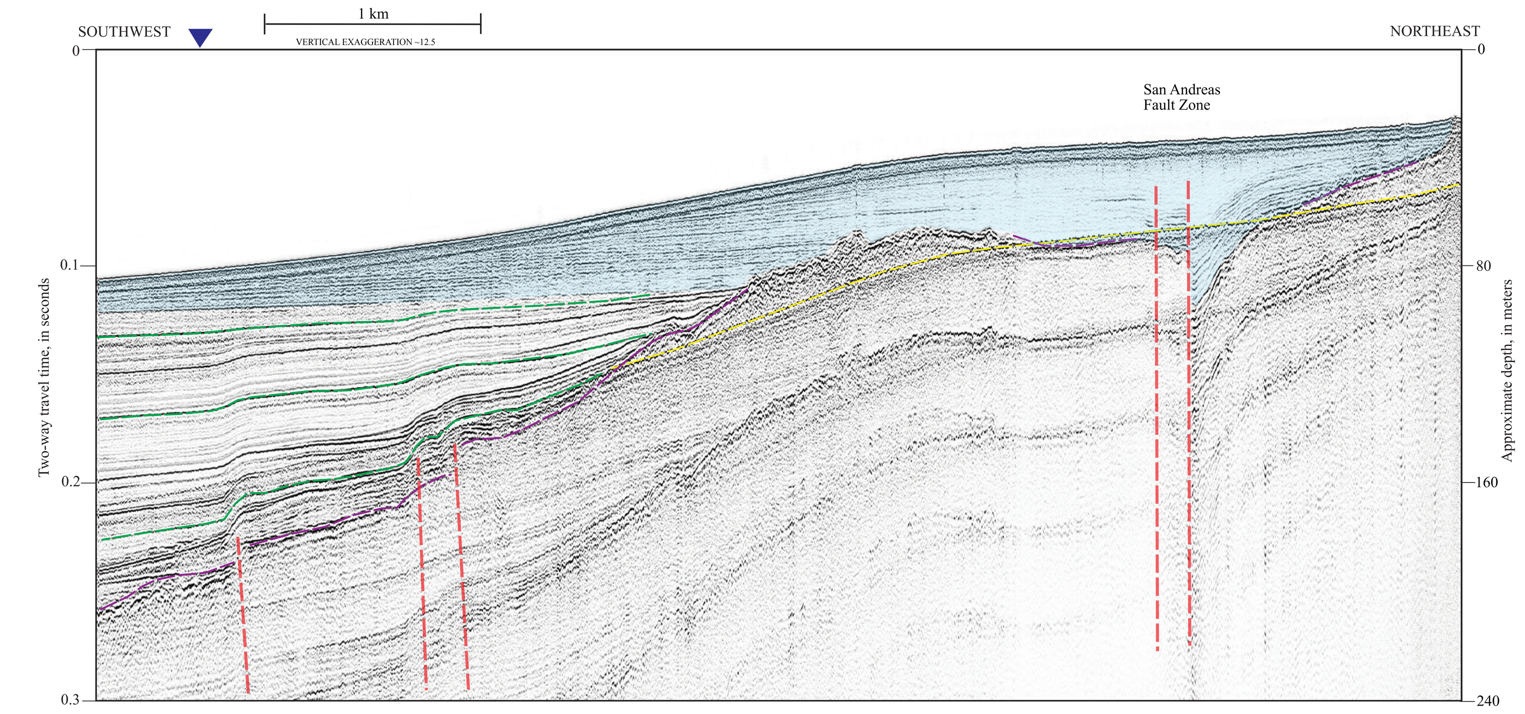
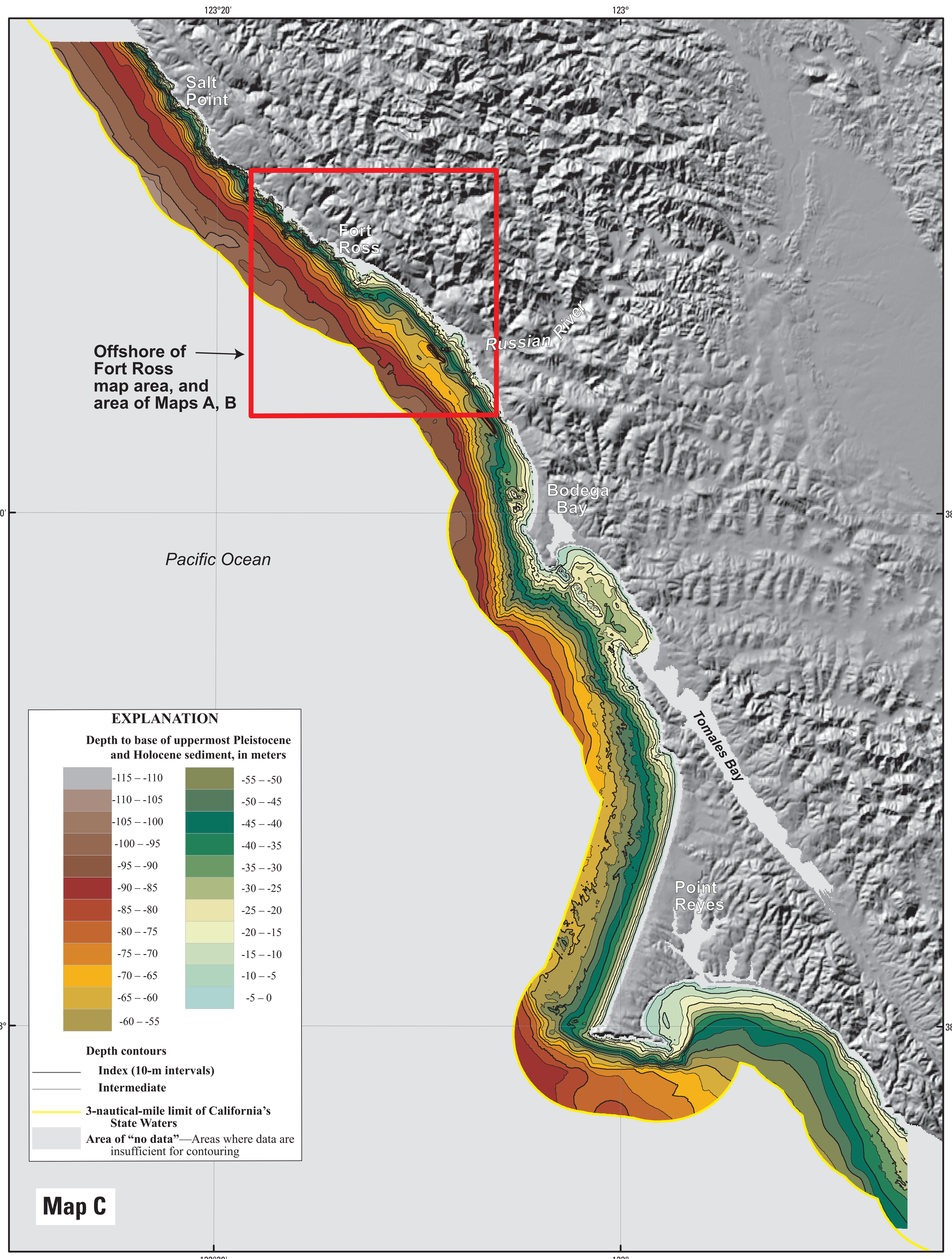
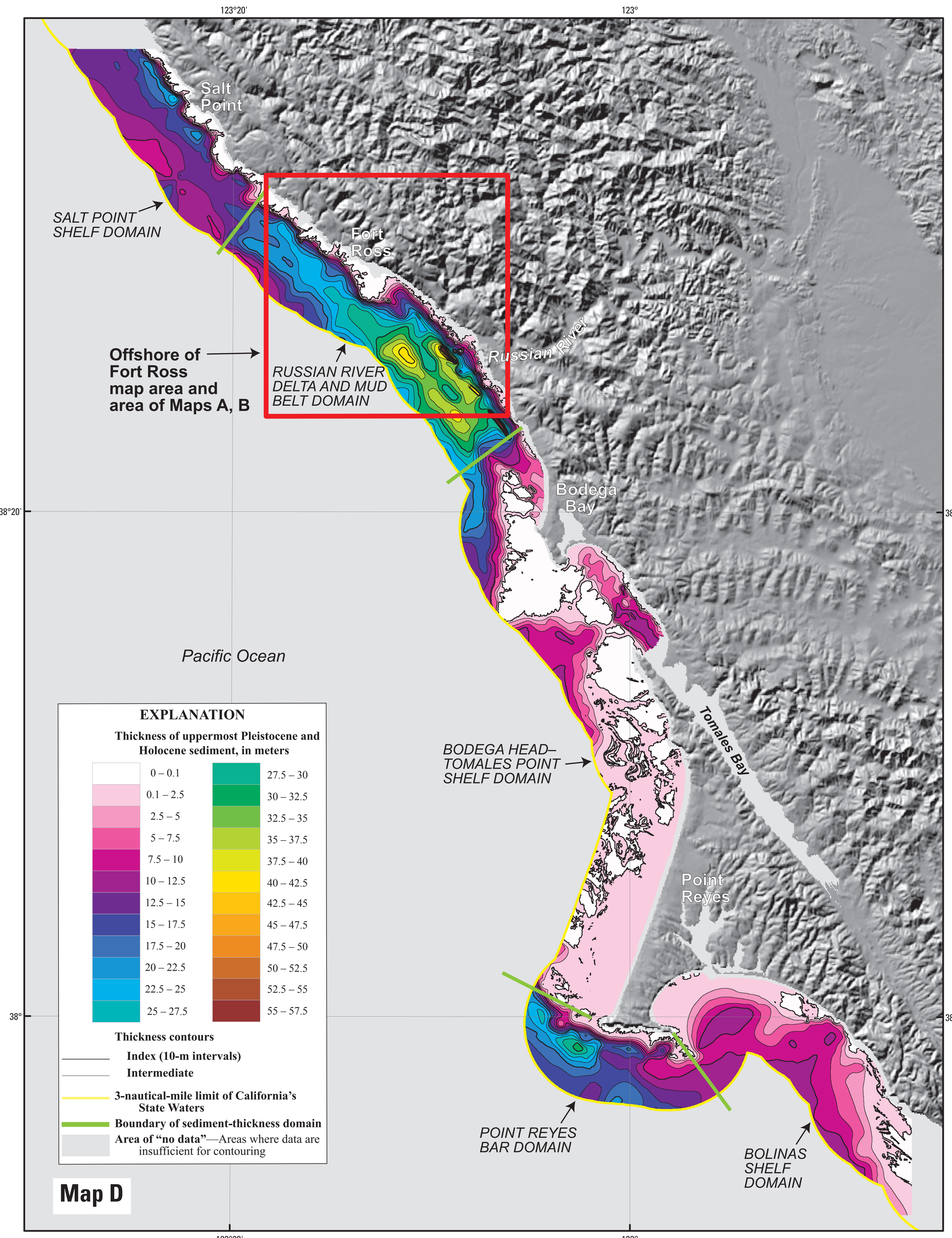
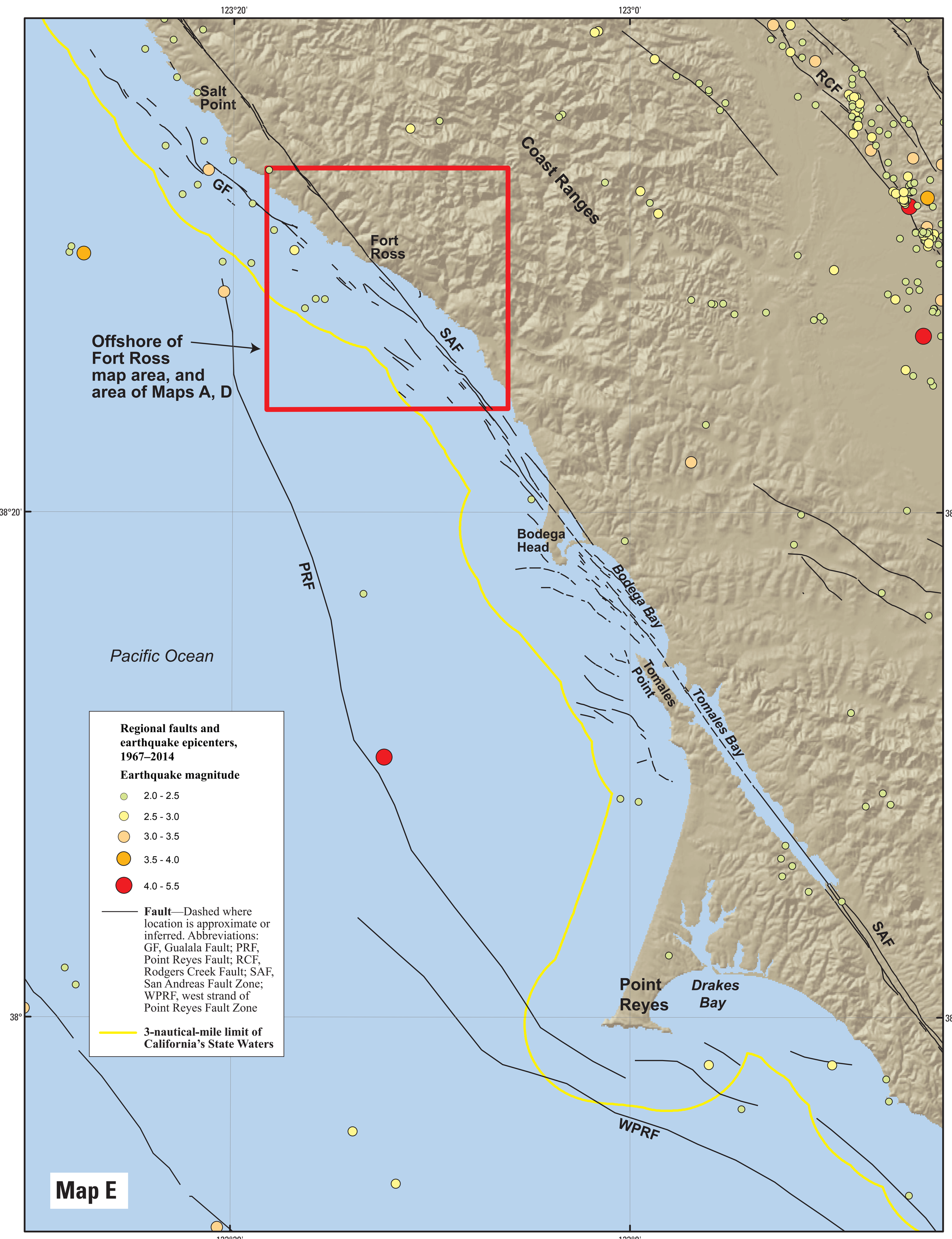


Figure 1. USGS high-resolution minisparker seismic-reflection profile PR–108 (collected in 2009 on survey S–8–09–NC), which crosses shelf west-southwest of mouth of Russian River; see Maps A, B for location. Dashed red lines show faults. Profile shows prominent asymmetric basin within San Andreas Fault Zone and gently dipping strata on its southwest flank. Blue shading shows inferred uppermost Pleistocene and Holocene shelf strata, deposited since last sea-level lowstand about 21,000 years ago. Underlying reflectors in southwestern (left) half of profile are of inferred Pleistocene age. Tertiary bedrock is inferred to underlie Pleistocene and Holocene sediments west of San Andreas Fault Zone. Dashed purple lines show unconformity with Tertiary bedrock. Dashed green lines highlight continuous reflections that reveal structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on Maps A through E).







Onshore elevation data from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:250 000

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Depth and thickness mapped by Samuel Y. Johnson and Stephen R. Hartwell, 2011–2012
GIS database and digital cartography by Stephen R. Hartwell
Manuscript approved for publication November 5, 2015

DISCUSSION

This sheet includes maps that show the interpreted thickness and the depth to base of uppermost Pleistocene and Holocene deposits in California's State Waters for the Offshore of Fort Ross map area (Maps A, B), as well as for a larger area that extends about 115 km along the coast from Salt Point to Drakes Bay on the south flank of the Point Reyes peninsula (Maps C, D, E) to establish regional context. This uppermost stratigraphic unit (blue shading in seismic-reflection profile of fig. 1; see also, figs. 1, 2, 3, 4, 6, 7, 9, 10, 11 on sheet 8) is inferred to have been deposited during the post–Last Glacial Maximum (LGM) sea-level rise in the last about 21,000 years (see, for example, Peltier and Fairbanks, 2006; Stanford and others, 2011). The unit commonly is characterized either by "acoustic transparency" or by parallel, low-amplitude, low- to high-frequency, continuous to moderately continuous, diffuse reflections (terminology from Mitchum and others, 1977). The acoustic transparency can be caused by extensive wave winnowing, which results in a uniform sediment grain size and the consequent lack of acoustic-impedance contrasts needed to produce seismic reflections. On the continental shelf, the contact with underlying units is a transgressive surface of erosion commonly marked by angularity, channeling, or a distinct upward change to lower amplitude, more diffuse reflections.

Offshore of Salt Point, about 3 km north of the Offshore of Fort Ross map area, the sequence of uppermost Pleistocene and Holocene deposits, which lies above a prominent unconformity, includes a lower, older stratigraphic unit made up of a downlapping sediment wedge that formed along the southwest flank of nearshore bedrock outcrops. Stratigraphic position, depth of occurrence, and reflection geometry suggest that this lower unit formed during the latter stages of the pre-LGM sea-level fall (about 30,000 to 21,000 years ago). Our regional thickness and depth-to-base maps (Maps C, D) combine these two uppermost Pleistocene and Holocene units in this northern part of the Salt Point to Drakes Bay region.

To make these maps, water bottom and depth to base of the post-LGM horizons were mapped from seismic-reflection profiles (fig. 1; see also, sheet 8). The difference in the two horizons was exported for every shot point as XY coordinates (UTM zone 10) and two-way travel time (TWT). The thickness of the post-LGM unit (Maps B, D) was determined by applying a sound velocity of 1,600 m/sec to the TWT. The thickness points were interpolated to a preliminary continuous surface, overlaid with zero-thickness bedrock outcrops (see sheet 10), and contoured, following the methodology of Wong and others (2012).

The thickness data points are dense along tracklines (about 1 m apart) and sparse between tracklines (1 km apart), resulting in minor contouring artifacts. To incorporate the effect of a few rapid thickness changes along faults, to remove irregularities from interpolation, and to reflect other geologic information and complexity, minor manual editing of the preliminary thickness contours was undertaken. Contour modifications and regridding were repeated several times to produce the final sediment-thickness maps. Information for the depth to base of the post-LGM unit (Maps A, C) was generated by adding the sediment-thickness data to water depths determined by multibeam bathymetry (see sheet 1).

The thickness of the post-LGM unit in the Offshore of Fort Ross map area ranges from 0 to 56 m (Map B), and the depth to base of the unit ranges from 9 to 100 m (Map A). Mean sediment thickness for the map area is 20.8 m, and total sediment volume is $2{,}393 \times 10^6$ m^3. The thickest sediment in the map area and within the larger Salt Point to Drakes Bay region (Maps B, D) is found in narrow, elongate fault-zone basins within the San Andreas Fault Zone. Outside of these small tectonic basins, the thickest post-LGM sediment in the Offshore of Fort Ross map area (as much as 41 m; Map B) and in the broader region (Map D) is found offshore of the mouth of the Russian River, at water depths of about 30 to 60 m. The Russian River has a very large sediment load (estimated 900,000 metric tons/yr; Farnsworth and Warrick, 2007), and the sediment thickness in this midshelf area is tied to this source. Sediment thickness diminishes to the northwest, forming a "mud belt" of fine-grained sediment that also is derived from the Russian River (Klise, 1983; Drake and Cacchione, 1985).

In the northern nearshore zone southwest of the San Andreas Fault (Maps A, B), bedrock forms seafloor outcrops that extend from about 500 m to 2 km offshore to water depths of about 50 m. In a few areas at the mouths of coastal watersheds (for example, Timber Cove Creek; Map B), lowstand fluvial channels were eroded into the nearshore bedrock then subsequently filled with sediment. Northeast of the San Andreas Fault, in the southeastern nearshore zone, the shallow (depths of 0 to 15 m) area between the shoreline and about 1 km offshore is characterized by discontinuous rocky outcrop and thin sediment cover.

Five different "domains" of sediment thickness are recognized on the regional sediment-thickness map (Map D), each with distinctive geologic controls: (1) The Salt Point shelf domain, located in the far northwestern part of the region, has a mean sediment thickness of 11.7 m. The thickest sediment (20 to 25 m) is found where a pre-LGM, regressive, downlapping sediment wedge formed above a break in slope that is controlled by a contact between harder bedrock and softer, folded Pleistocene strata. Sediment thinning in this domain within the outer parts of California's State Waters is the result of a relative lack of sediment supply from local watersheds, as well as a more distal Russian River source. (2) The Russian River delta and mud belt domain, located offshore of the Russian River, the largest sediment source on this part of the coast, has the thickest uppermost Pleistocene and Holocene sediment in the region (mean thickness, 21.1 m). The northward extension into the midshelf "mud belt" results from northward shelf-bottom currents and sediment transport (Drake and Cacchione, 1985). This domain includes a section of the San Andreas Fault Zone, which here is characterized by several releasing, right-stepping strands that bound narrow, elongate pull-apart basins; these sedimentary basins contain the greatest thickness of uppermost Pleistocene and Holocene sediment (about 56 m) in the region. (3) The Bodega Head–Tomales Point shelf domain, located between Bodega Head and the Point Reyes headland, contains the least amount of sediment in the region (mean thickness, 3.4 m). The lack of sediment primarily reflects decreased accommodation space (note shallower depth contours on Maps A, C) and limited sediment supply. (4) The Point Reyes bar domain, located west and south of the Point Reyes headland, is a local zone of increased sediment thickness (mean thickness, 14.3 m) created by bar deposition on the more protected south flank of the Point Reyes headland during rising sea level. (5) The Bolinas shelf domain, located east and southeast of the Point Reyes headland, has a thin sediment cover (mean thickness, 5.6 m), which likely reflects limited sediment accommodation space caused by tectonic uplift (water depths in this domain within California's State Waters are less than 45 m), as well as the limited sediment supply and high wave energy, capable of reworking and transporting shelf sediment to deeper water.

Map E shows the regional pattern of major faults and of earthquakes occurring between 1967 and April 2014 that have inferred or measured magnitudes of 2.0 and greater. Fault locations, which have been simplified, are compiled from our mapping within California's State Waters (see sheet 10) and from the U.S. Geological Survey's Quaternary fault and fold database (U.S. Geological Survey and California Geological Survey, 2010). Earthquake epicenters are from the Northern California Earthquake Data Center (2014), which is maintained by the U.S. Geological Survey and the University of California, Berkeley, Seismological Laboratory. The largest earthquake in the map area (M2.6, 5/18/2003) was located west of Fort Ross, within the deformation zone associated with the Gualala Fault. A notable lack of microseismicity on the adjacent San Andreas Fault has occurred since the devastating great 1906 California earthquake (M7.8, 4/18/1906), thought to have nucleated on the San Andreas Fault offshore of San Francisco (see, for example, Bolt, 1968; Lomax, 2005), about 90 km south of the map area.

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Local (Offshore of Fort Ross Map Area) and Regional (Offshore from Salt Point to Drakes Bay) Shallow-Subsurface Geology and Structure, California

By

Samuel Y. Johnson, Stephen R. Hartwell, Janet T. Watt, and Ray W. Sliter

2015

For sale by U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225, 1–888–ASK–USGS

Digital files available at http://dx.doi.org/10.3133/ofr20151211

Suggested Citation: Johnson, S.Y., Hartwell, S.R., Watt, J.T., and Sliter, R.W., 2015, Local (Offshore of Fort Ross map area) and regional (offshore from Salt Point to Drakes Bay) shallow-subsurface geology and structure, California, *sheet 9 in* Johnson, S.Y., Dartnell, P., Golden, N.E., Hartwell, S.R., Erdey, M.D., Greene, H.G., Cochrane, G.R., Kvitek, R.G., Manson, M.W., Endris, C.A., Dieter, B.E., Watt, J.T., Krigsman, L.M., Sliter, R.W., Lowe, E.N., and Chin, J.L. (S.Y. Johnson and S.A. Cochran, eds.), California State Waters Map Series—Offshore of Fort Ross, California: U.S. Geological Survey Open-File Report 2015–1211, pamphlet 37 p., 10 sheets, scale 1:24,000, http://dx.doi.org/10.3133/ofr20151211.

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20151211